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(54) **Valve assembly and breathing apparatus incorporating this valve assembly.**

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Valve assembly and breathing apparatus incorporating this valve assembly

The present invention relates to valve assemblies, and especially to demand valves for controlling the flow of pressurised respirable gas to breathing apparatus.

A valve assembly according to the prior art portion of claim 1 is known (from French Certificate of Addition No. 70219 to Patent No. 1 112 127) in which the gas inlet is closely adjacent to the flexible diaphragm. The inlet faces either directly towards or directly away from the diaphragm, and in either case the gas flowing in through the inlet can impinge on the diaphragm either directly or after being deflected by the valve member. This can result in the diaphragm being subject to aerodynamic forces, which may adversely affect the performance of the valve assembly.

The present invention provides a valve assembly which comprises a housing, an inlet for admitting gas into the housing from a source of gas at a superatmospheric pressure, a movable valve member which is capable of closing the gas inlet and which, in operation, is acted upon, at least when it is closed or nearly closed, by a force resulting from the pressure difference between the higher pressure gas upstream of the inlet and the lower pressure gas in the housing, the effect of which force is to tend to move the valve member to open the gas inlet and a flexible diaphragm of which one face is exposed to the ambient pressure and of which the other face is exposed to the pressure in the housing, the diaphragm being so connected to the valve member that, if the pressure in the housing exceeds the ambient pressure, at least by a certain amount, the diaphragm exerts a force on the valve member which tends to cause the valve member to move to close the inlet, characterised in that there is provided a cover member tending to impede the flow of gas within the housing from the inlet to the immediate vicinity of the diaphragm, which cover member is formed with an aperture through which the valve member extends and also with one or more apertures situated remote from the inlet, which apertures form the only means of communication for the flow of gas within the housing between the region of the housing that is immediately adjacent to the diaphragm and regions of the housing remote from the diaphragm.

The valve assembly may form part of a breathing apparatus, that is to say, the valve assembly may be a so-called "demand valve". It may be fixed directly to a face mask or it may be connected to a mouth piece, for example, in an aqualung.

Preferably, the movable valve member is so connected to the diaphragm that the diaphragm acts only to tend to move the valve member to close the inlet. The valve member is preferably connected to the diaphragm by means of a rigid member which is fixed to, and extends from, the centre of the diaphragm in a direction substantially normal to the plane of the central part of the diaphragm and into the interior of the housing. It will be appreciated that, as a result of the arrangement, the diaphragm experiences a restoring couple if it tends to turn or rock rather than execute a purely translational movement.

Advantageously, the movable valve member comprises a lever which is so mounted as to be pivotable about an axis, of which one part is arranged to open and close the inlet and which is connected to the diaphragm at a point spaced apart from the inlet along the length of the lever. The use of a pivotally mounted lever as the movable valve member has the advantage that, as is explained in greater detail hereinafter, it facilitates the achieving of the desired balance of forces. Preferably, the said one part of the movable valve member and the point at which the movable member is connected to the diaphragm are situated on the same side of the axis about which the lever is pivotable. That arrangement makes it possible to provide, for a given length of lever, a greater degree of leverage that can be provided if the part of the lever that is arranged to open and close the inlet and the point at which the lever is connected to the diaphragm are situated on opposite sides of the axis of pivot.

When the valve assembly is to serve as a demand valve for breathing apparatus, the arrangement and dimensions of the valve assembly are preferably such that, in operation, the valve assembly maintains the gas in the housing at a superatmospheric pressure. Such as "positive pressure" demand valve has a number of advantages over a demand valve in which the inlet to the housing is opened only when the gas in the housing is at a subatmospheric pressure. Thus, any leakage that occurs downstream of the gas inlet will be primarily a leakage of gas out of the breathing apparatus, rather than a leakage of, for example, noxious gas or water, into the apparatus which would be the case if the pressure downstream of the inlet ever fell below the ambient pressure.

Advantageously, there is provided external cover means arranged to protect the diaphragm and the diaphragm is exposed to ambient pressure only through one or more apertures in the external cover means, the aperture or apertures being so dimensioned as to tend to prevent unstable operation of the movable valve member. Satisfactory dimensions for the aperture or apertures can readily be ascertained by trial and error, the objective being to make them small enough to eliminate "flutter" of the movable valve member, or to reduce such flutter to an acceptable level, while at the same time not making the dimensions of the aperture

or apertures so small that the response of the valve to a change in the pressure within the housing is unduly retarded.

The invention also provides a breathing apparatus, which includes a face mask and a demand valve, wherein the demand valve is a valve assembly in accordance with the invention.

Advantageously, the housing of the valve assembly is formed by a part of the face mask.

The breathing apparatus may be provided with an ori-nasal mask and then the aperture or apertures in the cover member, other than the aperture through which the movable valve member extends, preferably communicate directly with the interior of the ori-nasal mask.

One form of valve assembly constructed in accordance with the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a front view of a face mask incorporating the second form of valve assembly; and

Fig. 2 is a cross-section taken on the line IV—IV in Fig. 1.

Referring to the accompanying drawings, the valve assembly is designed for use as a demand valve in breathing apparatus, and comprises a housing, which is indicated generally by the reference numeral 14 and which forms part of a face mask of a breathing apparatus.

The housing 14 is slightly tapered outwardly and is open at its larger, inner side where it is in air-tight engagement with the face seal 15 of the face mask. At its smaller, outer side, the housing 14 is formed with a central aperture which is closed by a flexible diaphragm 16. Fixed to the outer surface of the diaphragm 16 is a rigid circular plate 17 of dished form.

The diaphragm 16 and the plate 17 are formed with central apertures through which there passes one end portion, which is screw-threaded and of reduced diameter, of a pin which is indicated generally by the reference numeral 18. The diaphragm 16 and the plate 17 are clamped between the shoulder on the pin 18, formed where the screw-threaded end portion of the pin meets the main body of the pin, and a nut 19 on the screw-threaded portion of the pin.

The pin 18 terminates, at the end remote from the screw-threaded portion, in a ball 20, which is of larger diameter than the main body of the pin and which can seat in a recess formed towards the free end of a lever, which is indicated generally by the reference numeral 21. The portion 22 of the lever between the recess in which the ball 20 can seat and the free end of the lever is bifurcated to form a slot extending longitudinally with respect to the lever and through which the pin 18 can be inserted during assembly.

The lever 21 is pivotally mounted at 23 adjacent to the end of the lever that is remote from its free end. Secured to one side of the lever 21 close to the point 23 is a resilient pad 24 which, when the lever is in the position shown in Fig. 4, serves to close an air inlet formed by the open end of a supply conduit 25, which is formed in a member 26 which is sealed in an aperture in the housing 14.

The supply conduit 25 communicates *via* the hollow interior of an air inlet swivel elbow member 26 to an air supply tube 27.

Between the air inlet and the immediate vicinity of the diaphragm 16 there is interposed impedance means in the form of a plastics cover member 28, which is formed on the side nearest the air inlet with a slit 29 which is just wide enough to allow the lever 21 to pass through it without actually touching the cover member 28 and is long enough to ensure that the lever is free to turn far enough about the pivot 23 to open and close the air inlet. On the side remote from the air inlet, the cover member 28 is formed with a relatively large aperture 30 through which air can flow freely between the region bounded by the diaphragm 16 and the cover member 28, and the remainder of the interior of the housing 14.

The diaphragm 16 is protected against external damage by a cover 31, which may be formed of stainless steel, which is sealed to the housing 14 and which is formed, in its underside, with three apertures 32. As is explained hereinbefore, the dimensions of the apertures 32 are chosen to reduce or eliminate any tendency the lever 21 may have to flutter while at the same time not unduly retarding the response of the diaphragm 16 to pressure changes within the interior of the housing 14. The location of the apertures 32 in the underside of the cover 31 reduces the risk that any one of them will become blocked by dirt and the provision of more than one such aperture renders the consequence of blockage of an aperture less serious. Further, the apertures 32 are so located that they cannot be closed by the diaphragm 16.

Finally, the housing 14 is provided in one of its side walls with a conventional exhalation valve 33.

The breathing apparatus operates in the following way. The air supply tube 27 is supplied with air at a pressure of, say, 95 pounds per square inch gauge (650 kPa) and it is desired to maintain the pressure within the interior of the housing 14 within, say, the range of from 0.5 inch to 2.5 inches water gauge (125 to 625 Pa).

It will be appreciated that the high pressure air at the air inlet always exerts a force on the lever 21 that tends to open the inlet. When the lever 21 is in the position shown in Fig. 2, the inlet is closed by the resilient pad 24 on the lever and the pressure is a static pressure. When the lever 21 pivots clockwise as seen in Fig. 2 to open the inlet, the force exerted on the lever by the high pressure air flowing into the housing 14 is, at least in part, a kinetic reaction on the

lever caused by the air impinging on it.

On the other hand, given that the air pressure within the housing 14 is always above ambient pressure, the pressure difference across the diaphragm 16 itself tends to move the diaphragm outwards with the result that the effect of the pressure difference is to tend to move the lever 21 to close the air inlet. The force exerted on the pin 18, which is clamped to the diaphragm 16, does not, however, result solely from the pressure difference, but includes a component arising from the tension in the skirt portion of the diaphragm, that is to say, the portion of the diaphragm that lies radially outwards of the plate 17. With the configuration of the skirt portion of the diaphragm 16 shown in Fig. 2, that tension will tend to exert an inwards force (upwards as seen in Fig. 2) on the pin 18. The connection between the pin 18 and the lever 21 is, however, such that the pin never exerts a force on the lever which would tend to cause the lever to move to open the air inlet.

The desired balance of forces on the lever 21 is obtained, despite the great disparity between the pressure of the air supplied to the air inlet and the pressure that obtains in the housing 14, partly because of the leverage afforded by the lever 21 and partly because the effective area of the diaphragm 16 is much larger than the area of the air inlet.

It will be noted that the pin 18 and ball 20 act on the lever 21 at a distance from the pivot 23 that is greater than the distance between the inlet and the pivot. It will also be noted that the effective area of the diaphragm 16 is much greater than the area of the inlet. Consequently, the lever 21 moves to open or close the inlet in response to changes in the pressure within the housing 14 of the order of 1 inch water gauge (250 Pa) when the gas supply pressure is about 95 pounds per square inch gauge (650 kPa).

Fig. 2 shows the demand valve in a first position in which the lever 21 closes the gas inlet. The valve assumes the first position when the pressure in the housing 14 is greater than a predetermined value. In the first position, the moment applied to the lever 21 about the pivot 23 as a result of the force generated by the pressure difference across the diaphragm 16 (the first moment) is greater than the moment of the force applied to the lever as a result of the difference between the pressure in the conduit 25 and the pressure in the housing 14 (the second moment). If the pressure in the housing falls to a value below the predetermined value, for example, by inhalation by the wearer of the mask, the second moment becomes greater than the first moment and the valve assumes a second position in which the gas inlet is open. If the pressure in the housing 14 again rises to a value above the predetermined level, for example, as a result of exhalation of the wearer of the mask, the valve returns to the first position.

The maximum pressure reached within the housing 14 is determined by the setting of the exhalation valve 33, which should normally be such (in order to avoid the wastage of air or other respirable gas) that the air inlet and the exhalation valve are not open at the same time.

The construction of the valve assembly and the associated breathing apparatus can of course be varied in many respects without departing from the scope of the invention. In particular, the aperture 30 in the cover member 28 may be replaced by an aperture or apertures in the inner face (the upper face as seen in Fig. 2) leading directly to the interior of an ori-nasal mask, which, may itself be secured to, or integral with, the cover member 28.

Claims

1. A valve assembly which comprises a housing (14), an inlet (25) for admitting gas into the housing from a source of gas at a super-atmospheric pressure, a movable valve member (21) which is capable of closing the gas inlet (25) and which, in operation, is acted upon, at least when it is closed or nearly closed, by a force resulting from the pressure difference between the higher pressure gas upstream of the inlet (25) and the lower pressure gas in the housing (14), the effect of which force is to tend to move the valve member (21) to open the gas inlet (25), and a flexible diaphragm (16) of which one face is exposed to the ambient pressure and of which the other face is exposed to the pressure in the housing (14), the diaphragm (16) being so connected to the valve member (21) that, if the pressure in the housing (14) exceeds the ambient pressure, at least by a certain amount, the diaphragm (16) exerts a force on the valve member (21) which tends to cause the valve member (21) to move to close the inlet (25), characterised in that there is provided a cover member (28) tending to impede the flow of gas within the housing (14) from the inlet (25) to the immediate vicinity of the diaphragm (16), which cover member (28) is formed with an aperture (29) through which the valve member (21) extends and also with one or more apertures (30) situated remote from the inlet, which apertures form the only means of communication for the flow of gas within the housing (14) between the region of the housing that is immediately adjacent to the diaphragm (16) and regions of the housing (14) remote from the diaphragm (16).

2. A valve assembly as claimed in claim 1, characterised in that the movable valve member (21) is so connected to the diaphragm (16) that the diaphragm (16) acts only to tend to move the valve member (21) to close the inlet (25).

3. A valve assembly as claimed in claim 2, characterised in that the valve member (21) is connected to the diaphragm (16) by means of a rigid member (18) which is fixed to, and extends from, the centre of the diaphragm (16) in a

direction substantially normal to the plane of the central part of the diaphragm and into the interior of the housing (14).

4. A valve assembly as claimed in any one of claims 1 to 3, characterised in that the movable valve member comprises a lever (21) which is so mounted as to be pivotable about an axis (23), of which one part is arranged to open and close the inlet (25) and which is connected to the diaphragm (16) at a point spaced apart from the inlet (25) along the length of the lever (21).

5. A valve assembly as claimed in claim 4, characterised in that the said one part of the lever (21) and the point at which the lever is connected to the diaphragm (16) are situated on the same side of the axis (23) about which the lever (21) is pivotable.

6. A valve assembly as claimed in any one of claims 1 to 5, characterised in that the arrangement and dimensions are such that, in operation, the valve assembly maintains the gas in the housing (14) at a superatmospheric pressure.

7. A valve assembly as claimed in any one of claims 1 to 6, characterised in that there is provided external cover means (31) arranged to protect the diaphragm (16) and in that the diaphragm is exposed to ambient pressure only through one or more apertures (32) in the external cover means (31), the aperture or apertures (32) being so dimensioned as to tend to prevent unstable operation of the movable valve member (21).

8. A breathing apparatus, which includes a face mask and a demand valve, characterised in that the demand valve is a valve assembly as claimed in any one of claims 1 to 7.

9. A breathing apparatus as claimed in claim 8, characterised in that the housing (14) of the valve assembly is formed by a part of the face mask.

10. A breathing apparatus as claimed in claim 8, characterised in that it is provided with an ori-nasal mask and in that the aperture or apertures (30) in the cover member (28), other than the aperture (29) through which the movable valve member (21) extends, communicate directly with the interior of the ori-nasal mask.

Revendications

1. Assemblage de soupapes qui comprend un boîtier (14), un orifice d'admission (25) destiné à l'admission d'un gaz à l'intérieur de boîtier à partir d'une source de gaz à une pression supérieure à la pression atmosphérique, un obturateur mobile (21) qui est capable de fermer l'orifice d'admission de gaz (25) et qui, en fonctionnement, est sollicité, au moins lorsqu'il est fermé pratiquement fermé, par une force qui résulte de la différence de pression entre le gaz à plus haute pression en amont de l'orifice d'admission (25) et la gaz à plus faible pression dans le boîtier (14), l'effet de cette force étant de tendre à déplacer l'obturateur (21) afin d'ouvrir l'orifice d'admission de gaz (25), et un diaphragme flexible (16) dont une face est exposée à la pression ambiante et dont l'autre face est exposée à la pression qui règne dans le boîtier (14), le diaphragme (16) étant ainsi relié à l'obturateur (21) que, si la pression dans le boîtier (14) dépasse la pression ambiante, au moins d'une certaine valeur, le diaphragme (16) exerce une force sur l'obturateur (21) qui tend à provoquer le déplacement de l'obturateur (21) afin de fermer l'orifice d'admission (25) caractérisé en ce qu'il comprend un organe de couverture (28) qui tend à faire obstacle à l'écoulement du gaz à l'intérieur de boîtier (14) de l'orifice d'admission (25) jusqu'à la proximité immédiate du diaphragme (16), et qui présente une ouverture (29) dans laquelle s'étend l'obturateur (21), ainsi qu'une ou plusieurs ouvertures (30) éloignée(s) de l'orifice d'admission, et qui constitue(nt) les seuls moyens de communication, pour l'écoulement de gaz à l'intérieur du boîtier (14), entre la région du boîtier qui est immédiatement adjacente au diaphragme (16) et les régions du boîtier (14) qui sont éloignées du diaphragme (16).

2. Assemblage de soupapes selon la revendication 1, caractérisé en ce que l'obturateur mobile (21) est ainsi relié au diaphragme (16) que le diaphragme (16) a pour seul effet de tendre à déplacer l'obturateur (21) afin qu'il ferme l'orifice d'admission (25).

3. Assemblage du soupapes selon la revendication 2, caractérisé en ce que l'obturateur (21) est relié au diaphragme (16) au moyen d'un organe rigide (18) qui est fixé au centre du diaphragme (16) et s'étend à partir de ce dernier dans une direction sensiblement perpendiculaire au plan de la partie centrale du diaphragme et à l'intérieur du boîtier (14).

4. Assemblage de soupape selon l'une quelconque des revendications 1 à 3, caractérisé en ce que l'obturateur mobile comprend un levier (21) qui est monté pivotant sur un axe (23), dont une partie est agencée afin d'ouvrir et de fermer l'orifice d'admission (25) et qui est relié au diaphragme (16) en un point espacé de l'orifice d'admission (25) sur la longueur du levier (21).

5. Assemblage de soupapes selon la revendication 4, caractérisé en ce que ladite partie du levier (21) et le point par lequel le levier est relié au diaphragme (16) sont disposés du même coté de l'axe (23) autour duquel le levier (21) est monté pivotant 21.

6. Assemblage de soupape selon l'une quelconque des revendications 1 à 5, caractérisé en ce que la disposition et les dimensions sont telles que, en fonctionnement, l'assemblage de soupapes maintient le gaz dans le boîtier (14) à une pression supérieure à la pression atmosphérique.

7. Assemblage de soupapes selon l'une quelconque des revendications 1 à 6, caractérisé en

ce qu'il comprend des moyens de recouvrement externes (31) disposés de manière à protéger le diaphragme (16) et en ce que le diaphragme est exposé à la pression ambiante uniquement par une ou plusieurs ouvertures (32) pratiquées dans les moyens de recouvrement externes, l'ouverture ou les ouvertures étant ainsi dimensionnée(s) qu'elle(s) tend(ent) à empêcher tout fonctionnement instable de l'obturateur (21).

8. Appareil respiratoire, qui comprend un masque facial et une soupape d'aspiration, caractérisé en ce que la soupape d'aspiration est un assemblage de soupape selon l'une quelconque des revendications 1 à 7.

9. Appareil respiratoire selon la revendication 8, caractérisé en ce que le boîtier (14) de l'assemblage de soupapes est constitué par une partie du masque facial.

10. Appareil respiratoire selon la revendication 8, caractérisé en ce qu'il comprend un masque bucco-nasal et en ce que l'ouverture ou les ouvertures (30) dans l'organe de couverture (28) qui est on sont différentes de l'ouverture (29) dans laquelle s'étend l'obturateur mobile (21) communique(nt) directement avec l'intérieur du masque bucco-nasal.

Patentansprüche

1. Ventilanordnung mit einem Gehäuse (14), einem Einlaß (25) zum Zuführen von Gas in das Gehäuse aus einer Gasquelle mit überatmosphärischem Druck, einem beweglichen Ventilteil (21), das den Gaseinlaß (25) verschließen kann und auf das im Betrieb wenigstens dann, wenn es geschlossen oder nahezu geschlossen ist, eine Kraft einwirkt, die aus der Druckdifferenz zwischen dem Gas mit höherem Druck stromaufwärts vom Einlaß (25) und dem Gas mit niedrigerem Druck in dem Gehäuse (14) resultiert, wobei die Wirkung dieser Kraft darin besteht, das Ventilteil (21) in Öffnungsrichtung für den Gaseinlaß (25) zu bewegen, und einer flexiblen Membran (16), die von der einen Seite dem Umgebungsdruck ausgesetzt ist, während die andere Seite hiervon dem Druck in dem Gehäuse (14) ausgesetzt ist, wobei die Membran (16) so mit den Ventilteil (21) verbunden ist, daß dann, wenn der Druck in dem Gehäuse (14) dem Umgebungsdruck um wenigstens einen bestimmten Betrag übersteigt, die Membran (16) eine Kraft auf das Ventilteil (21) ausübt, die das Ventilteil (21) zum Schließen des Einlasses (25) beaufschlagt, dadurch gekennzeichnet, daß ein Deckelteil (28) vorgesehen ist, um den Gasfluß innerhalb des Gehäuses (14) vom Einlaß (25) zur unmittelbaren Nachbarschaft der Membran (16) zu behindern, wobei der Deckelteil (28) mit einer Öffnung (29), durch die sich das Ventilteil (21) erstreckt, sowie mit einer oder mehreren Öffnungen (30) versehen ist, die vom Einlaß abgewandt angeordnet sind, wobei die Öffnungen die einzigen Mitgel für den Gasfluß innerhalb des Gehäuses (14) zwischen dem Bereich des Gehäuses, der sich unmittelbar benachbart zur Membran (16) befindet, und Bereichen des Gehäuses (14) entfernt von der Membran (16) bilden.

2. Ventilanordnung nach Anspruch 1, dadurch gekennzeichnet, daß das bewegliche Ventilteil (21) derart mit der Membran (16) verbunden ist, daß die Membran (16) nur in Schließrichtung auf das Ventilelement (21) zum Schließen des Einlasses (25) einwirkt.

3. Ventilanordnung nach Anspruch 2, dadurch gekennzeichnet, daß das Ventilteil (21) mit der Membran (16) über ein starres Teil (18) verbunden ist, das in der Mitte der Membran (16) befestigt ist und sich von dort in einer Richtung im wesentlichen senkrecht zur Ebene des mittleren Teils der Membran und in das Innere des Gehäuses (14) erstreckt.

4. Ventilanordnung nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß das bewegliche Ventilteil einen Hebel (21) umfaßt, der derart montiert ist, daß er um eine Achse (23) schwenkbar ist, von dem ein Teil angeordnet ist, um den Einlaß (25) zu öffnen und zu schließen, und der mit der Membran (16) an einer Stelle mit Abstand zum Einlaß (25) längs der Länge des Hebels (21) verbunden ist.

5. Ventilanordnung nach Anspruch 4, dadurch gekennzeichnet, daß der eine Teil des Hebels (21) und die Stelle, an der der Hebel an der Membran (16) befestigt ist, auf der gleichen Seite der Achse (23) angeordnet sind, um die der Hebel (21) schwenkbar ist.

6. Ventilanordnung nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß die Anordnung und die Abmessungen derart sind, daß im Betrieb die Ventilanordnung das Gas im Gehäuse (14) auf einem überatmosphärischen Druck hält.

7. Ventilanordnung nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß ein äußeres Deckelteil (31) zum Schutz der Membran (16) angeordnet vorgesehen ist und daß die Membran dem Umgebungsdruck nur durch eine oder mehrere Öffnungen (32) in dem äußeren Deckelteil ausgesetzt wird, wobei die Öffnung oder Öffnungen so dimensioniert sind, daß sie eine unstabile Betätigung des beweglichen Ventilteils (21) verhindern.

8. Atemgerät mit einer Gesichtsmaske und einem Bedarfsventil, dadurch gekennzeichnet, daß das Bedarfsventil eine Ventilanordnung nach einem der Ansprüche 1 bis 7 ist.

9. Atemgerät nach Anspruch 8, dadurch gekennzeichnet, daß das Gehäuse (14) der Ventilanordnung durch einen Teil der Gesichtsmaske gebildet wird.

10. Atemgerät nach Anspruch 8, dadurch gekennzeichnet, daß es mit einer Mund-Nasen-Maske versehen ist und daß die Öffnung oder Öffnungen (30) in dem Deckelteil (28) verschieden von der Öffnung (29), durch die sich das bewegliche Ventilteil (21) erstreckt, direkt mit dem Inneren der Mund-Nasen-Maske in Verbindung stehen.

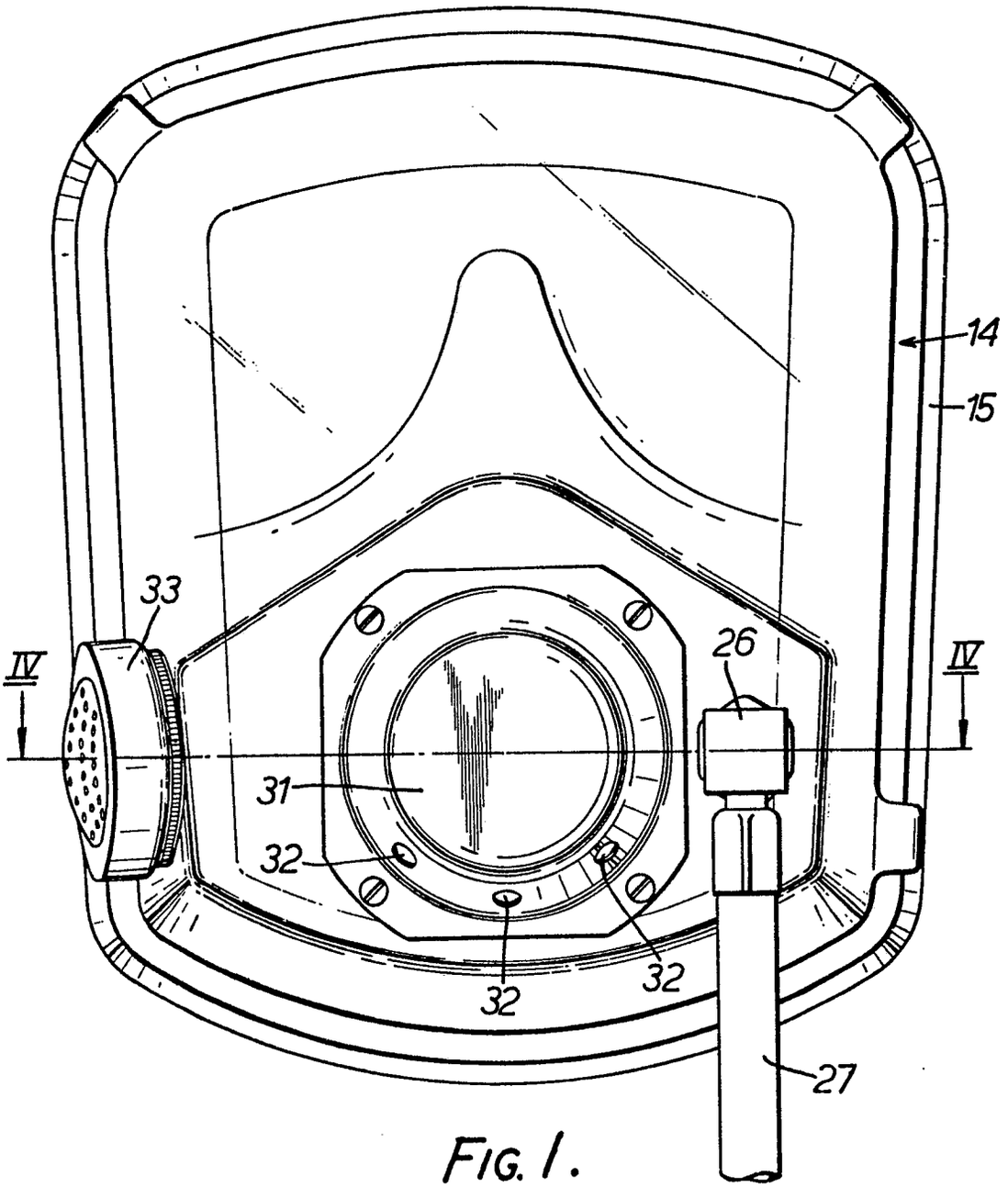

FIG. 1.

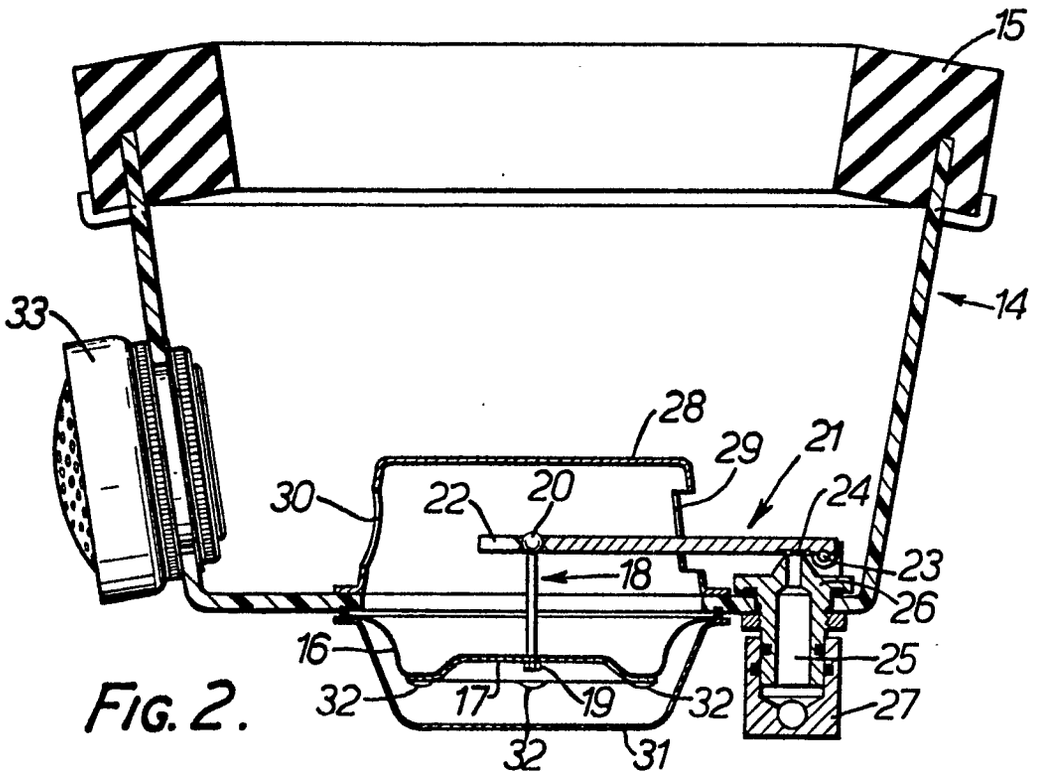

FIG. 2.